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ERDC/CHL TR-16-7

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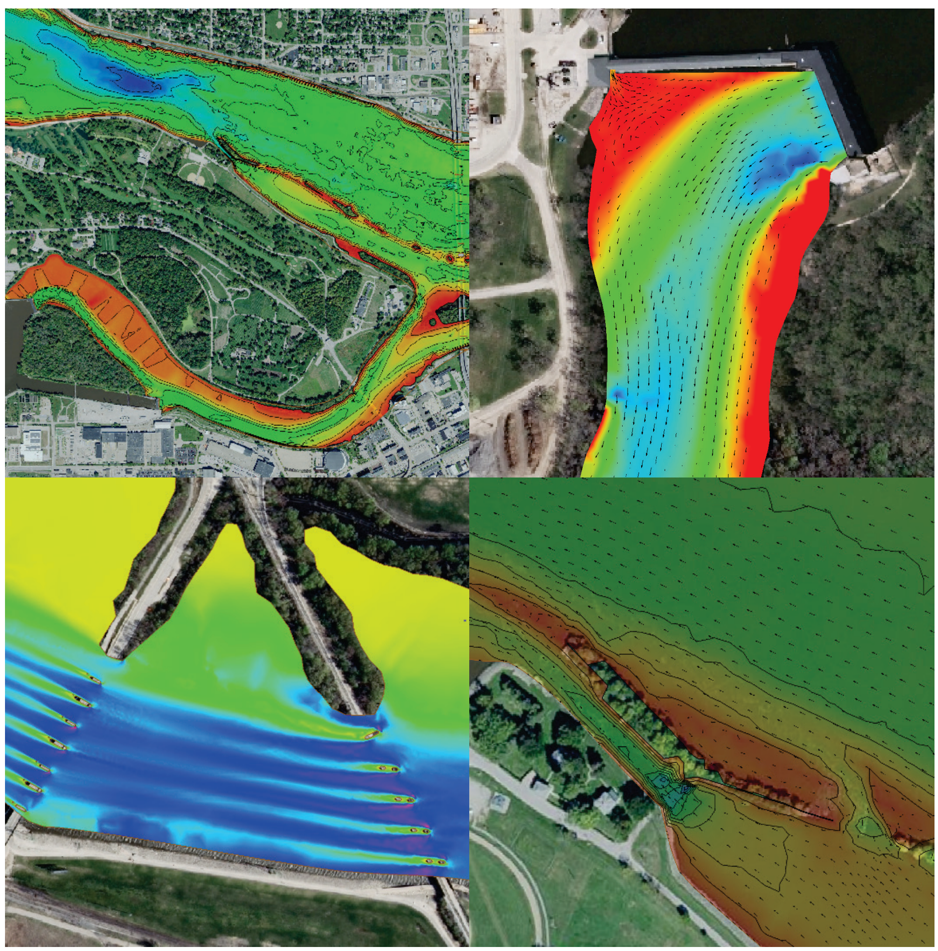
Rock Island Arsenal Power Dam

Numerical Hydraulic Model Investigation of Channel Capacity for Power Generation

Travis A. Dahl, Marielys Ramos-Villanueva, and Ronald E. Heath

June 2016



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Final report

Prepared for U.S. Army Corps of Engineers Louisville District
Louisville, KY 40201-0059

Under Project 446851, "RIA Moline Pool H&H Study"

Abstract

The Mississippi River at Rock Island, IL, flows through Lock and Dam 15 and two power plants. One power plant is operated by the City of Moline, IL, while the other is under control of the U.S. Army Garrison Rock Island Arsenal. The Rock Island Arsenal is considering upgrades to its generating capacity, and there are questions regarding the impacts of the additional flow in the channel between Rock Island and the City of Moline due to these upgrades. Flow in Pool 15 (Moline Pool) and Pool 16 (Sylvan Slough) was modeled with Adaptive Hydraulics (AdH). The models were run for three different Mississippi River discharge scenarios (35,000, 74,000, 130,000 cfs). Increased discharge from the Rock Island plant had minimal effects in Sylvan Slough until combined power plant discharges exceeded 10,000 cfs. At higher flows, when combined with the 35,000 cfs Mississippi River scenario, the tailwater at both dams starts to increase. The existing capacity of the channel in the Moline Pool effectively limits discharge to 8,000 cfs at low Mississippi River flows. Dredging of the Moline Pool channel would allow larger power plant flows, but there would still be significant decreases in the available head for power generation at all Mississippi River discharges.

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Preface

This study was conducted for the U.S. Army Corps of Engineers Louisville District (LRL) under Project 446851, "RIA Moline Pool H&H Study." The technical monitor for the Louisville District was Kenneth H. Lamkin. The technical monitor for the U.S. Army Engineer Garrison Rock Island Arsenal (RIA) was Christian E. Hawkinson.

Field data collection in support of this study was conducted by personnel of the U.S. Army Corps of Engineers, Rock Island District (CEMVR), and the contributions of Toby J. Hunemuller, Daniel McBride, Scott A. Bullock, John M. Hayes, Bradley D. Palmer, and Michael L. Scudder are gratefully acknowledged. Terry Waller of the ERDC-CHL Field Data Collection and Analysis Branch (CEERD-HN-F) assisted with field data collection planning. Jonathan A. Hall (CELRL) conducted Geographic Information System processing of bathymetric data that was essential to model development. Additionally, Hall prepared Plate 12 and Plate 13 (Appendix A) in this report. Hunemuller, Jay D. Richter (RIA), and David DeGan of Fluor Corporation provided historical data and insights into system operation and behavior.

The work was performed by the River Engineering Branch (CEERD-HFR) of the Flood and Storm Protection Division (CEERD-HF), U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL). At the time of publication, Keith W. Flowers was Chief, CEERD-HFR; Ty V. Wamsley was Chief, Flood and Storm Protection Division, CEERD-HF; and William R. Curtis, CEERD-HT, was the Technical Director for Flood and Coastal Storm Protection. The Director of ERDC-CHL was José E. Sánchez.

At the time of publication of this report, COL Bryan S. Green was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
miles (U.S. statute)	1,609.347	meters
feet per second	0.3048	meters per second
cubic feet per second	0.02831685	cubic meters per second

1 Introduction

1.1 Background

The U.S. Army Garrison Rock Island Arsenal (RIA) is considering the potential of increasing the generating capacity at the RIA Power Dam. The Moline Power Dam and the RIA Power Dam are sited between the Moline Pool and Sylvan Slough, a side channel of the Mississippi River near Rock Island, IL. Water levels in the Moline Pool are regulated primarily by Mississippi River Locks and Dam (L&D) 15 and to a lesser extent at low flows by a longitudinal dike that extends upstream just over 3 miles from an old lock chamber on the opposite side of the RIA from the power dams. Typically, the net head at both power dams is approximately 12 ft with a combined power dam release of approximately 8,000 cfs. High flows on the Mississippi River, typically occurring during the spring thaw, increase tailwater at L&D 15 and both power dams, reducing the head available for power production (U.S. Army Corps of Engineers [USACE] 1981).

1.2 Objectives

At the request of the U.S. Army Engineer District Louisville (LRL), the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL), conducted a numerical, hydraulic model investigation to evaluate the impacts of increasing flows through the Moline Pool and Sylvan Slough to support additional power generation. The overall objective of this investigation was to quantify the capacities of the intake and outflow channels of the two powerhouse structures and define the effects increased hydropower releases might have on stages and flow distribution within the system and thereby impact available head at both power dams. In general, any increase in flow would result in additional energy losses within Moline Pool and Sylvan Slough, reducing available head at the power dams to some degree. Therefore, a primary objective was to estimate the magnitude of potential energy losses through the Moline Pool and Sylvan Slough. An additional objective was to determine if channel modifications would be necessary to accommodate larger releases.

2 Model Development

2.1 Approach

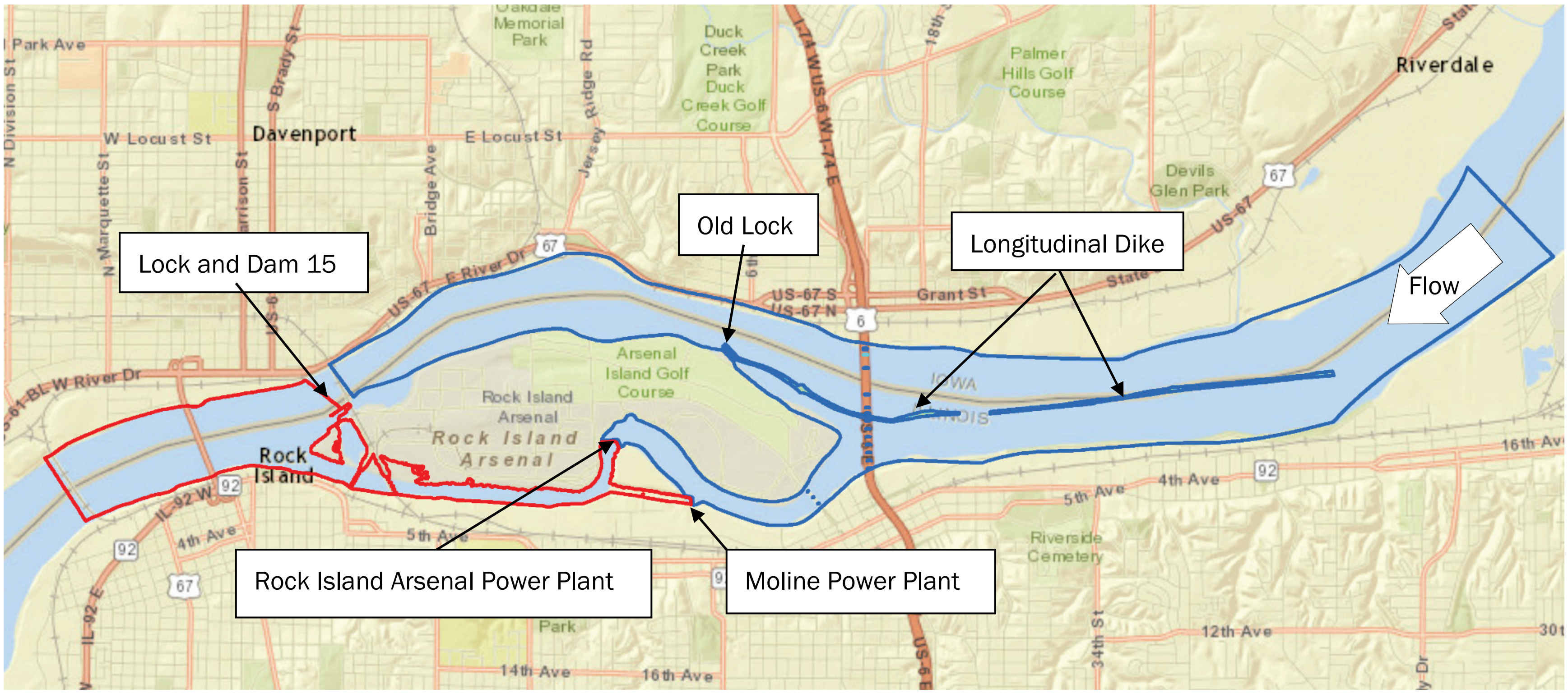
The hydraulic model investigation was conducted with the Adaptive Hydraulics (AdH) numerical modeling system to solve the two-dimensional (2D), depth-averaged, shallow water equations describing open channel flow. AdH is a multiphysics, finite element code capable of automatically refining the unstructured computational mesh when necessary to resolve gradients in the flow field (Berger 1999).

The primary advantage of a 2D model for this investigation was the direct computation of energy losses at junctions and changes in flow distribution around islands and structures induced by varying prescribed hydropower releases. The primary limitation was that the near-field, three-dimensional (3D) flow fields at the entrances and exits of individual generating units would be significantly more complex than fields produced by a 2D model. A 3D model would not significantly improve estimates of available head for hydropower generation, and therefore the additional time and cost required was not considered appropriate for this investigation. A 3D numerical or physical model investigation would be appropriate for optimization of entrance and exit configurations during design of the proposed upgrades.

2.2 Mesh development

Separate models were developed downstream and upstream of the RIA Power Dam. The downstream model is referred to in this report as the Sylvan Slough model, and the upstream model is referred to as the Moline Pool model (Figure 1). Both models include a portion of the Mississippi River. The horizontal datum for both models was the North American Datum of 1983 (NAD83), Illinois State Plane, West, in feet. Bathymetry was referenced to Mean Sea Level of 1912 (MSL 1912) in feet.

Figure 1. Location map showing Sylvan Slough (red outline) and Moline Pool (blue outline) model limits, as well as relevant features.



2.2.1 Moline Pool

The Moline Pool finite element mesh, containing 72,231 elements and 36,977 nodes, was developed from bathymetric surveys collected in 2014, more detailed bathymetry collected in 2014 along the longitudinal dike, and data from an existing Finite Element Surface Water Modeling System (FESWMS) model prepared for the Iowa Department of Transportation (HDR Engineering 2008).* None of these datasets provided a definitive elevation for the top of the longitudinal dike. The best estimate for the top elevation of the longitudinal dike is 560.0 ft, equivalent to 1 ft below normal pool†, and this is what was used in the model. Water depths along the right descending side of the Moline Pool between the Moline Power Dam and RIA Power Dam were too shallow to be determined by hydrographic survey. An average elevation of 558.5 ft was assumed in this region, based on the shallowest depth recorded by the survey boat.

The mesh domain extended from the RIA Power Dams upstream to the Mississippi River and included approximately 6.6 miles of the Mississippi River upstream of L&D 15. Mesh resolution varied from 2 ft near bridge piers to 330 ft in the Mississippi River.

An inflow boundary was placed at the upstream end of the model. Outflow boundaries were placed at the Moline and Arsenal power plants with prescribed flows. A constant head outflow boundary was placed at L&D 15 with the elevation chosen based on the regulation rule curves.

2.2.2 Sylvan Slough

The Sylvan Slough finite element mesh, containing 44,893 elements and 23,229 nodes, was developed from a combination of the bathymetric surveys collected during 2014 and data from an existing FESWMS model prepared for the Iowa Department of Transportation (HDR Engineering 2008).* The mesh domain extended from the RIA and Moline Power Dams downstream to the Mississippi River and included approximately 1.5 miles of the Mississippi River downstream of L&D 15 to the Centennial Bridge. Mesh resolution varied from 0.6 ft near bridge piers to 132 ft in the Mississippi River.

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* Daniel McBride (MVR), Jonathan Hall (LRL), and Kenneth Lamkin (LRL), personal communications, Oct 2014.

† Toby Hunemuller (MVR), personal communication, 8 Jan 2015.

Inflows to the model were prescribed at L&D 15 and both power dams. Stage was prescribed at the downstream Mississippi River boundary and adjusted as required to match observed stages at L&D 15.

2.3 Model circumstantiation

Under typical operating conditions, the head differential at the power dams is approximately the same as the head differential at L&D 15. Available observations were not sufficient to rigorously determine longitudinal stage profiles through Moline Pool and Sylvan Slough. Therefore, the assignment of hydraulic roughness coefficients, presented in Table 1 and Table 2, relied heavily on prior studies and professional judgment. Additionally, a significant effort was made to model the size and placement of bridge piers within the AdH finite element mesh to capture the effects of these flow obstructions on energy losses within the system.

2.3.1 Moline Pool

Table 1. Hydraulic roughness coefficients applied in the Moline Pool model.

Description	Manning's n-value
Mississippi River – Main Channel	0.021
Mississippi River – South of Longitudinal Dike	0.025
Longitudinal Dike	0.040
Island at Head of Slough	0.040
Shallow Area Surrounding Island at Head of Slough	0.030
Upper Sylvan Slough/Power Plant Headraces	0.025
Shallow Area on North/Right Descending Side of Headrace Between Power Plant Intakes	0.040

The Moline Pool model was tested by comparing to acoustic Doppler current profiler (ADCP) data collected on 24 Sep 2014, looking in particular at the flow splits around features in the channel.*

* ADCP data provided by Scott Bullock (MVR) and Kenneth Lamkin on 3 Oct 2014.

2.3.2 Sylvan Slough

Table 2. Hydraulic roughness coefficients applied in the Sylvan Slough model.

Description	Manning's n-value
Mississippi River	0.021
Sylvan Slough	0.025
RIA Power Dam Exit Channel	0.025
Moline Dam Exit Channel	0.025
Stone Scour Protection at Railroad Bridge	0.016

The Sylvan Slough model was tested by comparing against the ADCP flow and velocity data collected for the Pool 15 Hydrology Study (Upper) on 24 Sep 2014. *

* ADCP data provided by Scott Bullock (MVR) and Kenneth Lamkin on 3 Oct 2014.

3 Analysis of Channel Capacity

3.1 Flow conditions evaluated

Three different Mississippi River flows were evaluated, representing a range of flow conditions that can be expected to occur within the range of power dam operations. The flows were 35,000, 74,000, and 130,000 cfs. Each Mississippi River flow was evaluated with a set of seven combinations of Moline and Rock Island Arsenal power plant discharges (Table 3). For all power plant release scenarios, the total Mississippi River discharge was held constant, and the discharge through L&D 15 was adjusted to compensate for variations in power plant releases.

Table 3. Power plant release scenarios evaluated.

Moline Power Plant Discharge (cfs)	Rock Island Arsenal Power Plant Discharge (cfs)				
	4,200	4,920	6,000	8,000	12,000
0				X	
2,000			X	X	
3,100		X			
4,000	X			X	X

For this analysis, all RIA plant releases were passed through the left descending side of the power dam. As previously noted, the water depths in Moline Pool immediately upstream of the right descending side of the power dam are shallow. Diversion of significant flows through the right side would require construction of an entrance channel of sufficient capacity to pass the flows. In the opinion of the authors, utilization of the right side of the dam to pass additional flows would result in a slight decrease in tailwater in Sylvan Slough due to a more favorable alignment of outflows with the exit channel.

3.2 Existing conditions

Mississippi River flows of 35,000 cfs were modeled for each of the power plant discharge scenarios shown in Table 3. The resulting headwater and tailwater stages adjacent to the Arsenal Power Dam are shown in Figure 2. Headwater and tailwater stages for the Moline Power Dam are displayed in Figure 3. These results are also summarized in Table 4. In general, the head differences across both dams are within 1 ft for combined power plant outflows of 8,000 cfs. The head differences start to decrease as outflows at the Arsenal power plant are increased past 8,000 cfs. The model indicated that the Arsenal power plant is unable to pass 12,000 cfs with the current channel configuration in the Moline Pool (Pool 15). Plate 1 (Appendix A) shows the modeled water surface profiles through the Moline Pool along the line shown in Plate 2 (Appendix A). Plate 3 (Appendix A) shows the water surfaces profiles through Sylvan Slough along the line shown in Plate 4 (Appendix A).

Model results for Mississippi River flows of 74,000 cfs are shown in Figure 4, Figure 5, and Table 5. Head differences for this scenario are approximately 2 ft less than at the lower Mississippi River discharge. Significant (> 1 ft) head differences start to occur at the Arsenal Power Plant for combined hydropower discharges of 10,000 cfs (8,000 cfs Arsenal/ 2,000 cfs Moline). Combined power plant discharges of 16,000 cfs (12,000 cfs Arsenal/4,000 cfs Moline) cause head differences to decrease by over 2 ft at the Moline plant and 5 ft at the Arsenal plant. Water surface profiles for Moline Pool are shown on Plate 5 (Appendix A) and for Sylvan Slough on Plate 6 (Appendix A). An example water surface elevation contour map of the entire Moline Pool model domain at the largest power plant flow is included as Plate 7 (Appendix A). The water surface at the dam can be converted to stage values by subtracting the gage zero elevation of 542.49 ft (MSL 1912). Plate 8 (Appendix A) shows the same water surface for the entrances to the power plants, including the substantial areas of drying near the approach to the Arsenal power plant. The water surface at the same flow combination for the Sylvan Slough model is shown in Plate 9 (Appendix A).

Figure 6, Figure 7, and Table 6 summarize the model results for Mississippi discharges of 130,000 cfs. The high flow in the Mississippi River greatly reduces the head differences at the power plants. Increased plant flows do not have a significant impact on the head difference until the combined power plant discharge reaches 16,000 cfs (12,000 cfs Arsenal/4,000 cfs Moline). Plate 10 and Plate 11 (Appendix A) show the water surface profiles for Moline Pool and Sylvan Slough, respectively.

Flows through the old lock chamber on the North side of Rock Island were also extracted from the model runs and are listed in Table 7. Combined discharges at the two power plants of up to 8,000 cfs do not have a noticeable effect. Impacts of power plant flows of 10,000 cfs or more are most noticeable at low Mississippi River flows but still amount to only a small decrease in the flow through the old lock chamber.

Figure 2. Arsenal Power Plant – Stage at Moline Pool (P15) and Sylvan Slough (TW) for a Mississippi River discharge of 35,000 cfs. In the legend, Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively. Note that the Moline Pool was unable to pass 12,000 cfs in this model configuration.

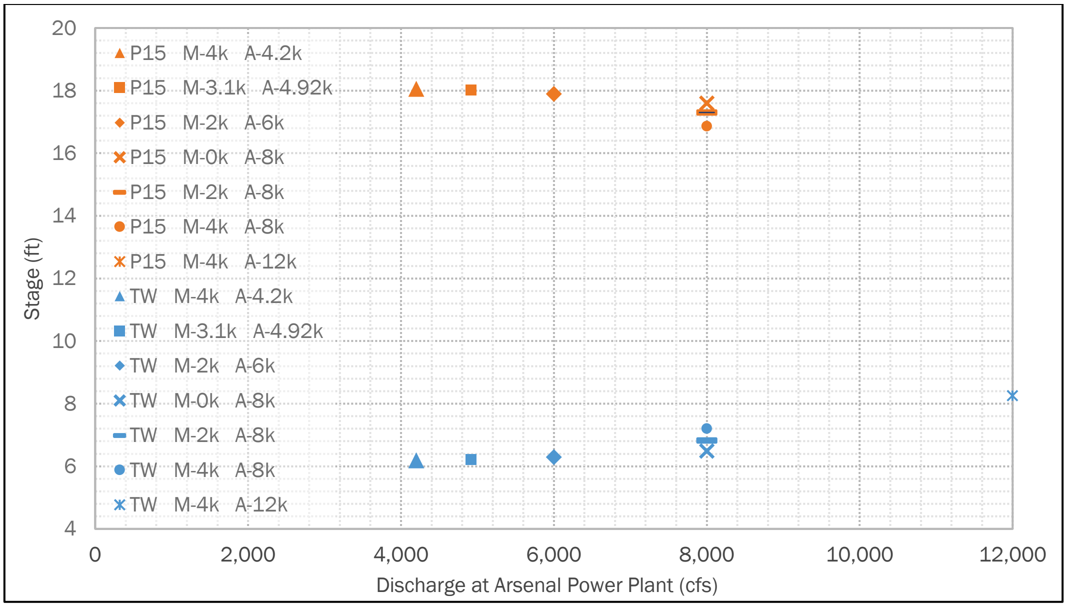

Figure 3. Moline Power Plant – Stage at Moline Pool (P15) and Sylvan Slough (TW) for a Mississippi River discharge of 35,000 cfs. In the legend, Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively. Note that the Moline Pool was unable to pass 12,000 cfs in this model configuration.

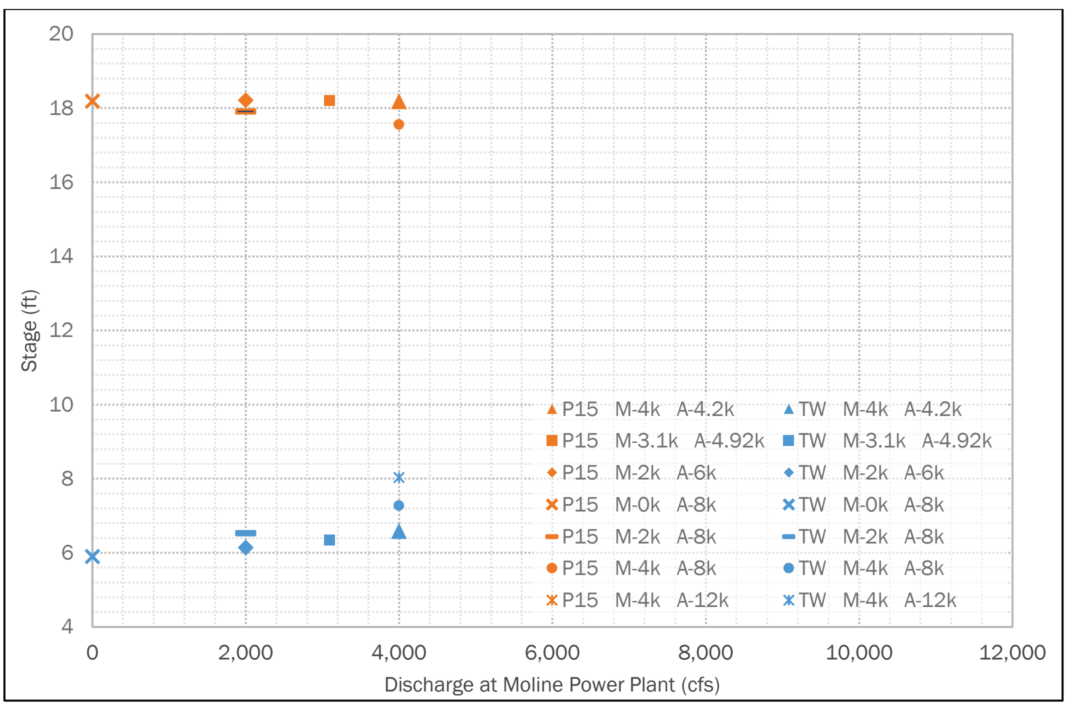

Figure 4. Arsenal Power Plant – Stage at Moline Pool (P15) and Sylvan Slough (TW) for a Mississippi River discharge of 74,000 cfs. In the legend, Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively.

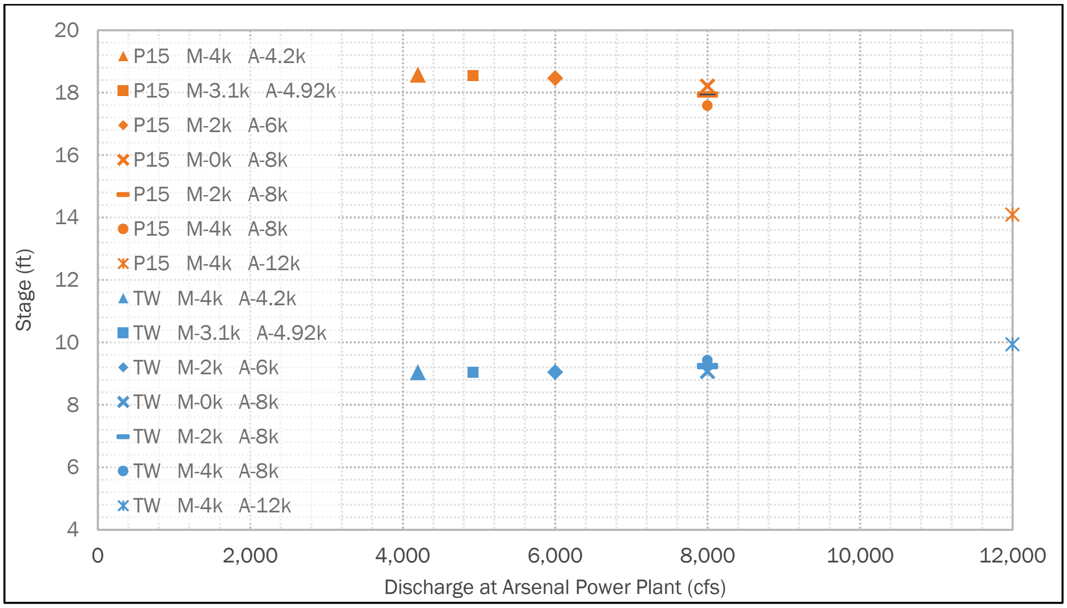

Figure 5. Moline Power Plant – Stage at Moline Pool (P15) and Sylvan Slough (TW) for a Mississippi River discharge of 74,000 cfs. In the legend, Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively.

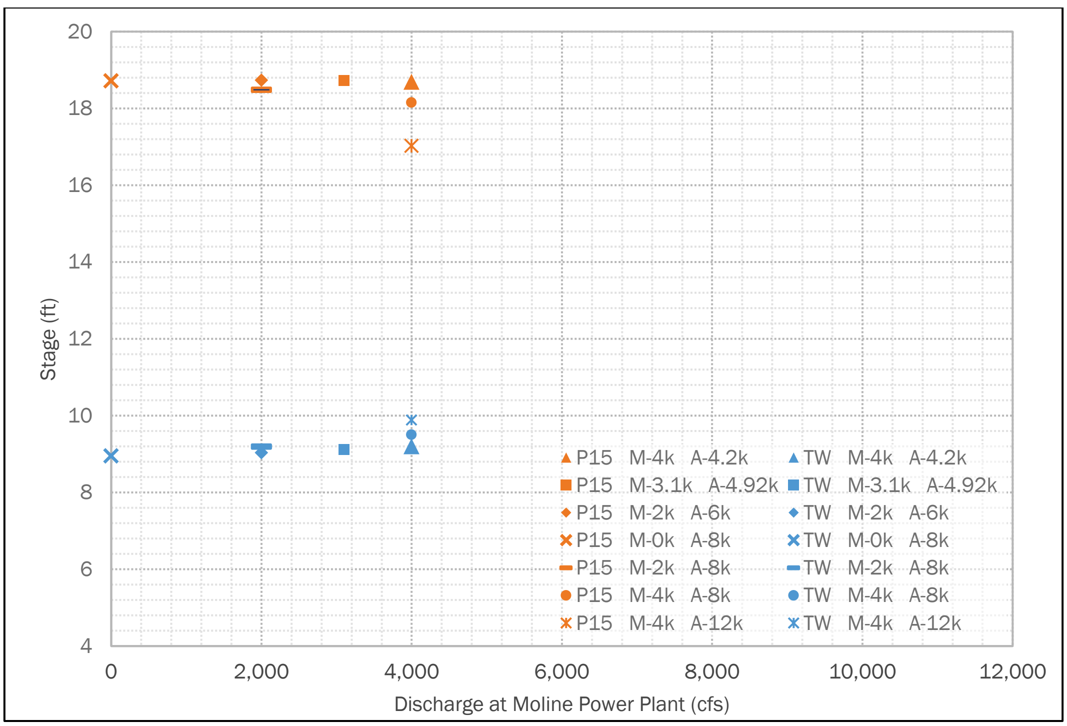

Figure 6. Arsenal Power Plant – Stage at Moline Pool (P15) and Sylvan Slough (TW) for a Mississippi River discharge of 130,000 cfs. In the legend, Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively.

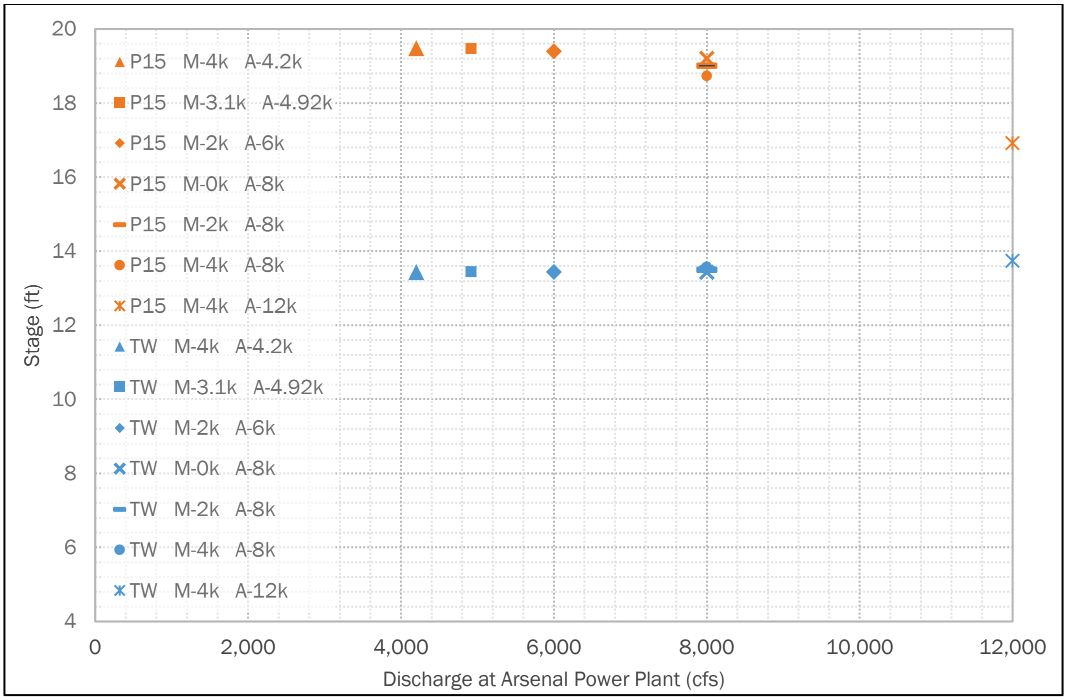

Figure 7. Moline Power Plant – Stage at Moline Pool (P15) and Sylvan Slough (TW) for a Mississippi River discharge of 130,000 cfs. In the legend, Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively.

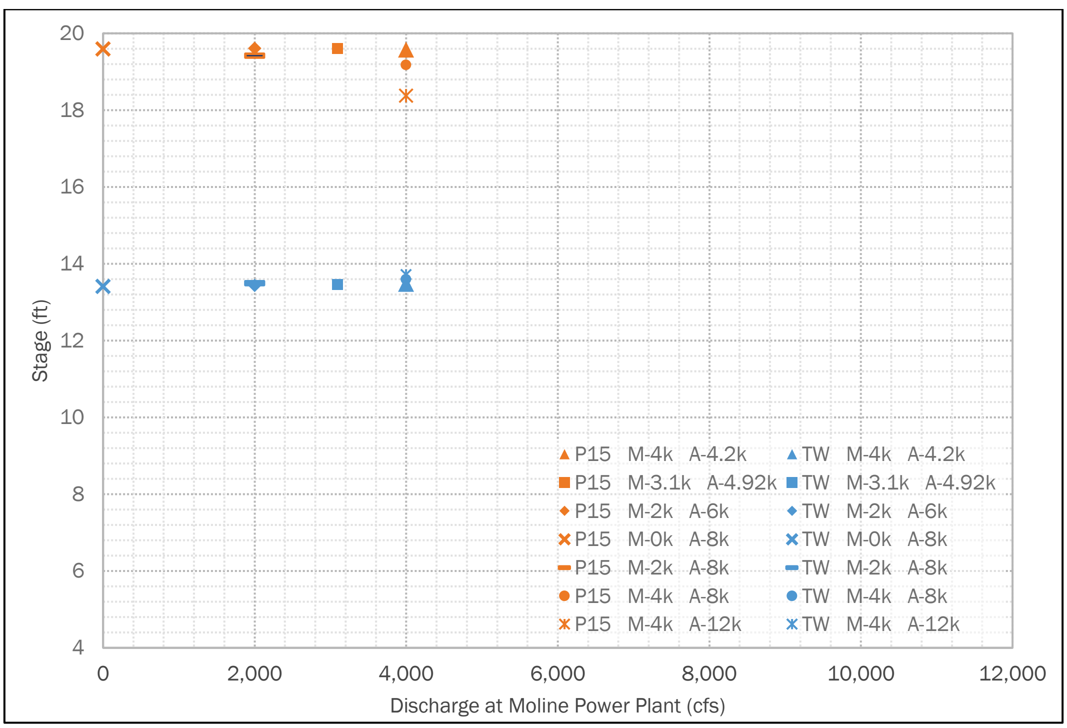

Table 4. Computed stages and heads at power plants for a Mississippi River discharge of 35,000 cfs. Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively.

Scenario	Arsenal Power Dam				Moline Power Dam			
	Discharge (cfs)	Pool 15 Stage (ft)	Tailwater Stage (ft)	ΔH (ft)	Discharge (cfs)	Pool 15 Stage (ft)	Tailwater Stage (ft)	ΔH (ft)
A-4.2k cfs M-4k cfs	4,200	18.05	6.19	11.87	4,000	18.18	6.59	11.60
A-4.92k cfs M-3.1k cfs	4,920	18.00	6.21	11.79	3,100	18.21	6.35	11.86
A-6k cfs M-2k cfs	6,000	17.90	6.29	11.61	2,000	18.21	6.14	12.07
A-8k cfs M-0k cfs	8,000	17.60	6.48	11.12	0	18.19	5.89	12.29
A-8k cfs M-2k cfs	8,000	17.30	6.83	10.47	2,000	17.91	6.53	11.38
A-8k cfs M-4k cfs	8,000	16.86	7.20	9.66	4,000	17.56	7.27	10.29
A-12k cfs M-4k cfs	12,000	*	8.26	*	4,000	*	8.03	*

* Existing channel capacity in the Moline Pool was not sufficient to pass 12,000 cfs downstream to the RIA Power Dam.

Table 5. Computed stages and heads at power plants for a Mississippi River discharge of 74,000 cfs. Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively.

Scenario	Arsenal Power Dam				Moline Power Dam			
	Discharge (cfs)	Pool 15 Stage (ft)	Tailwater Stage (ft)	ΔH (ft)	Discharge (cfs)	Pool 15 Stage (ft)	Tailwater Stage (ft)	ΔH (ft)
A-4.2k cfs M-4k cfs	4,200	18.58	9.05	9.53	4,000	18.69	9.20	9.49
A-4.92k cfs M-3.1k cfs	4,920	18.55	9.04	9.51	3,100	18.73	9.11	9.62
A-6k cfs M-2k cfs	6,000	18.46	9.05	9.41	2,000	18.73	9.04	9.70
A-8k cfs M-0k cfs	8,000	18.21	9.07	9.14	0	18.71	8.95	9.77
A-8k cfs M-2k cfs	8,000	17.95	9.25	8.70	2,000	18.48	9.19	9.29
A-8k cfs M-4k cfs	8,000	17.58	9.43	8.15	4,000	18.15	9.50	8.65
A-12k cfs M-4k cfs	12,000	14.10	9.94	4.16	4,000	17.02	9.88	7.14

Table 6. Computed stages and heads at power plants for a Mississippi River discharge of 130,000 cfs. Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively.

Scenario	Arsenal Power Dam				Moline Power Dam			
	Discharge (cfs)	Pool 15 Stage (ft)	Tailwater Stage (ft)	ΔH (ft)	Discharge (cfs)	Pool 15 Stage (ft)	Tailwater Stage (ft)	ΔH (ft)
A-4.2k cfs M-4k cfs	4,200	19.49	13.44	6.04	4,000	19.57	13.47	6.10
A-4.92k cfs M-3.1k cfs	4,920	19.47	13.44	6.03	3,100	19.60	13.45	6.14
A-6k cfs M-2k cfs	6,000	19.40	13.44	5.96	2,000	19.61	13.44	6.17
A-8k cfs M-0k cfs	8,000	19.21	13.43	5.78	0	19.59	13.40	6.19
A-8k cfs M-2k cfs	8,000	19.01	13.50	5.51	2,000	19.41	13.49	5.93
A-8k cfs M-4k cfs	8,000	18.74	13.57	5.16	4,000	19.17	13.59	5.59
A-12k cfs M-4k cfs	12,000	16.92	13.74	3.18	4,000	18.37	13.72	4.65

Table 7. Computed flows through old lock chamber on north side of Rock Island Arsenal.

Arsenal Flow	Moline Flow	Lock Chamber Flow (cfs)		
		35kcfs	74kcfs	130kcfs
4,200	4,000	1,674	4,191	7,338
4,920	3,100	1,659	4,230	7,348
6,000	2,000	1,661	4,258	7,349
8,000	0	1,661	4,236	7,349
8,000	2,000	1,489	4,033	7,237
8,000	4,000	1,310	3,869	7,119
12,000	4,000	*	3,606	6,866

* Existing channel capacity in the Moline Pool was not sufficient to pass 12,000 cfs downstream to the RIA Power Dam.

3.3 Channel dredging for increased flow

The existing capacity of the Rock Island Arsenal power plant head race is not sufficient to allow for 12,000 cfs of flow to pass through the dam at lower Mississippi River flows. An alternative model was created that would require dredging in two locations (Plate 12 and Plate 13 [Appendix A]). A total of 33,600 yd^3 of material were removed in the model between Rock Island Arsenal and the island at the upstream end of Sylvan Slough. The deep portion of the channel between the Moline and Arsenal power plants was also widened from approximately 80 ft to 120 ft through the dredging of 92,000 yd^3 of material. The removal of this material created sufficient capacity in the channel to pass a total of 16,000 cfs through the two power plants (12,000 cfs at RIA and 4,000 cfs at Moline) during low Mississippi River flows. Widening only the channel between Rock Island Arsenal and the Moline Powerhouse would allow 10,000 cfs of flow while just dredging the channel at the head of Sylvan Slough would allow 11,000 cfs of flow. The resulting stages and head differences for this case are shown in Table 8. Water surface profiles through Moline Pool under this scenario are shown in Plate 14 (Appendix A).

Table 8. Computed stages and heads at power dams for a Mississippi River discharge of 35,000 cfs, after dredging. Moline and Rock Island Arsenal power plant flows are indicated by M and A, respectively.

Scenario	Arsenal Power Dam				Moline Power Dam			
	Discharge (cfs)	Pool 15 Stage (ft)	Tailwater Stage (ft)	ΔH (ft)	Discharge (cfs)	Pool 15 Stage (ft)	Tailwater Stage (ft)	ΔH (ft)
A-12k cfs M-4k cfs	12,000	14.02	8.26	5.76	4,000	15.63	8.03	7.60

4 Conclusions and Recommendations

Increasing flow through the RIA Powerhouse to 8,000 cfs (while maintaining existing flows through the Moline Powerhouse) appears viable if head reductions are economically acceptable, where head is defined as the difference in water elevation across the structure. Computed head reductions were greatest for the low Mississippi River condition (35,000 cfs discharge) and decreased as Mississippi River flows increased. For the 8,000 cfs RIA Powerhouse release, the maximum head reduction was approximately two-thirds of a foot, with most of the reduction attributable to a decrease in Moline Pool stage at the Power Dam.

With existing channel geometry, larger RIA Powerhouse flows produce significantly greater head reductions and may not be viable through the entire range of Mississippi River flows. For the low Mississippi River condition, the computed head reductions were nearly equally balanced between increased tailwater and decreased pool stages. For the higher Mississippi River flows, most of the head reduction was attributable to increased energy losses and corresponding stage decreases in the Moline Pool.

RIA Powerhouse flows larger than approximately 9,000 cfs would require dredging or channel modification in the upstream portion of Sylvan Slough (Moline Power Pool).

- A 50% increase in channel width between RIA and Moline Powerhouses would allow 10,000 cfs.
- Dredging the channel at the head of Sylvan Slough, adjacent to the Arsenal, would allow 11,000 cfs.
- Combining both scenarios would allow 12,000 cfs.

Use of the right descending portion of the RIA Power Dam would require additional dredging to construct an entrance channel. The potential for sediment accumulation should be considered in the design of the channel. In general, flows split into two streams have less capacity to carry sediment than the capacity of the combined flow upstream of the split.

Bridge pier scour may be a concern for larger flow diversions through Sylvan Slough. Maximum scour depth is primarily dependent on stage at the piers, which will increase to some degree with larger flow diversions. Additionally, increased flow may increase the rate of scour or reduce the stability of existing scour protection at bridge piers and along the outer banks of bends.

Larger outflows from Sylvan Slough will increase crosscurrents near the confluence with the Mississippi River. Plans should be coordinated with USACE operations and the navigation industry to address any potential concerns with navigation in or out of the downstream lock approach at L&D 15.

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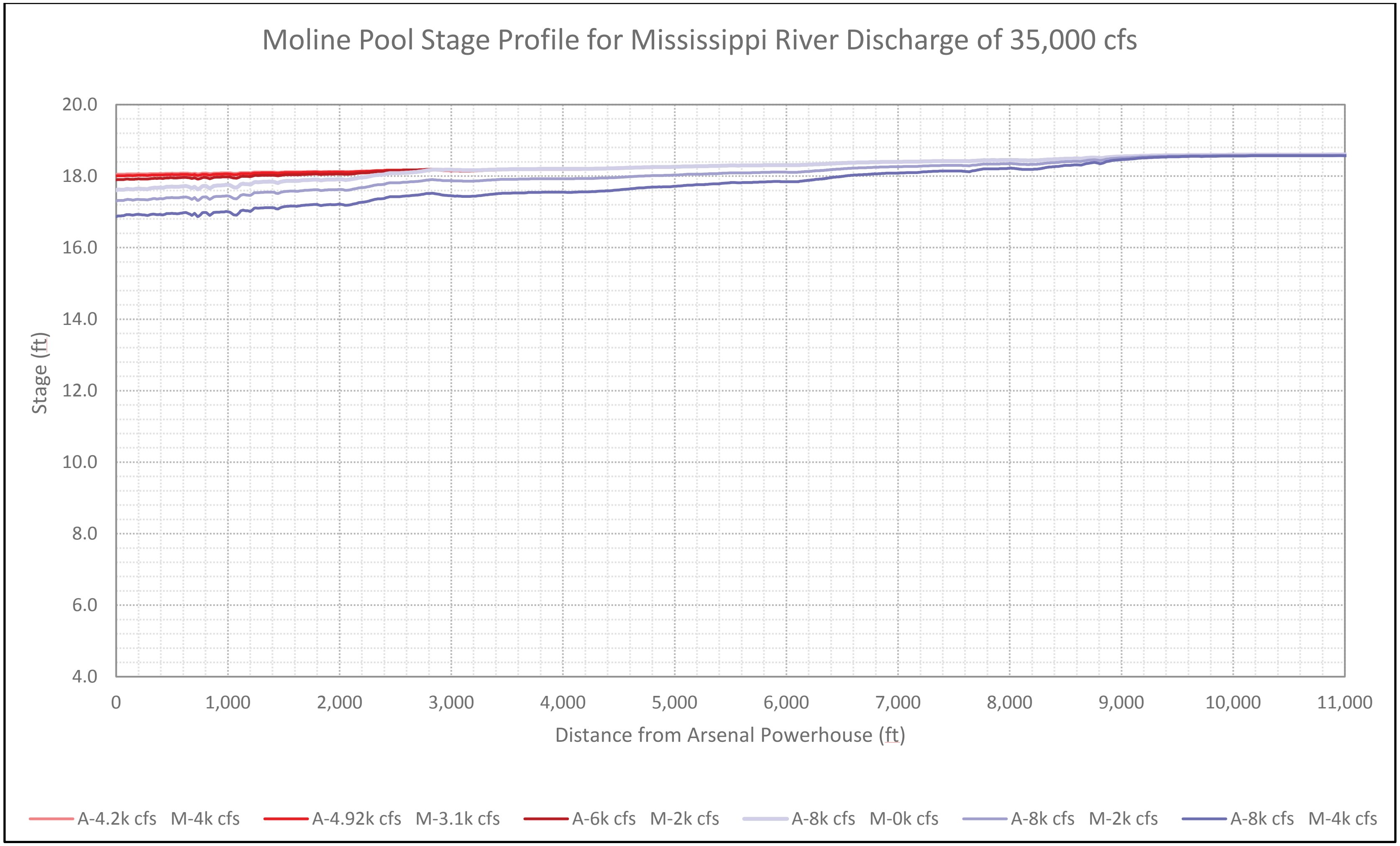
Appendix A: Plates 1 – 14

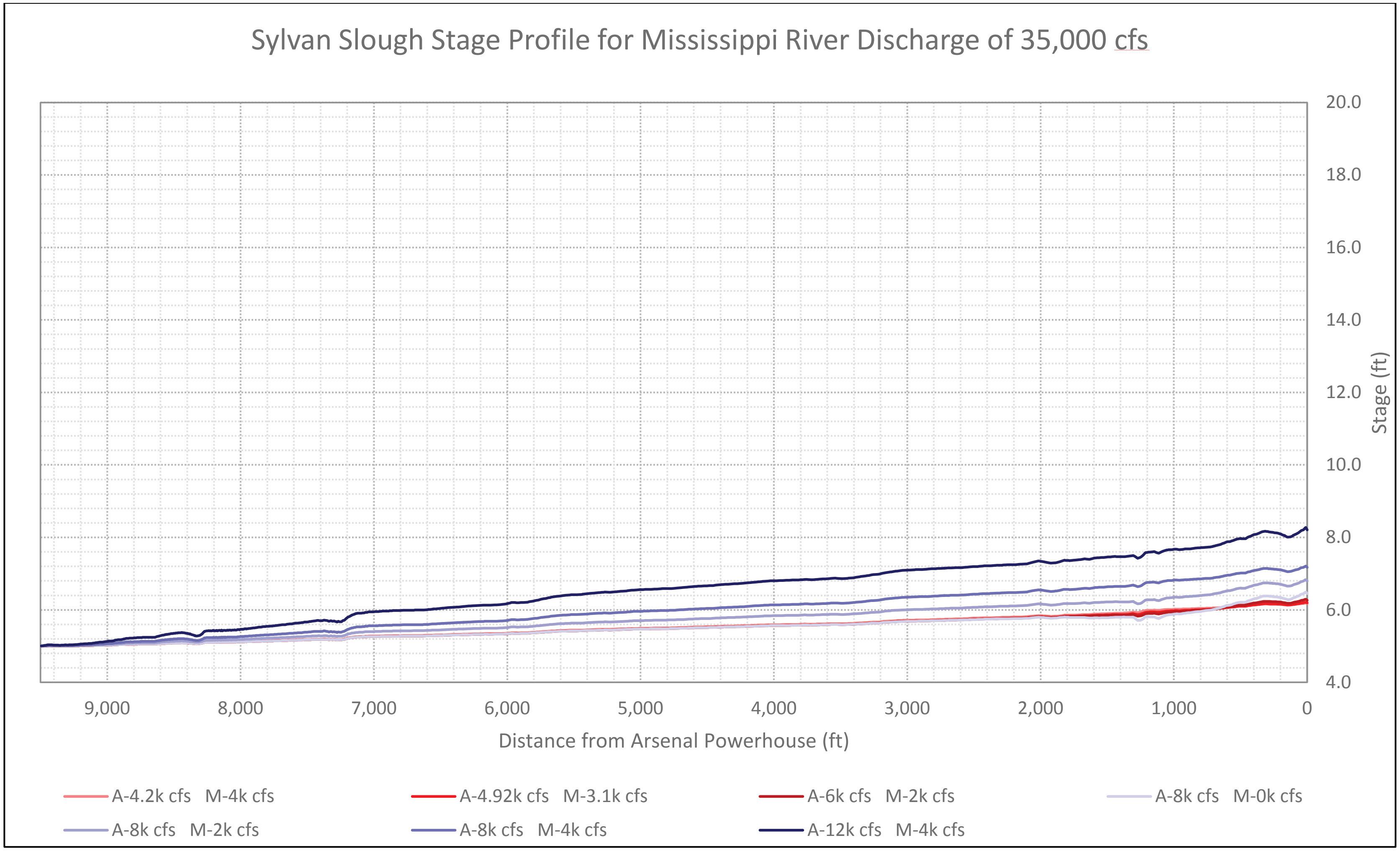


Moline Pool Stage Profile for Mississippi River Discharge of 35,000 cfs
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
Stage (ft)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
Distance from Arsenal Powerhouse (ft)
A-4.2k cfs M-4k cfs
A-4.92k cfs M-3.1k cfs
A-6k cfs M-2k cfs
A-8k cfs M-0k cfs
A-8k cfs M-2k cfs
A-8k cfs M-4k cfs

Plate 1

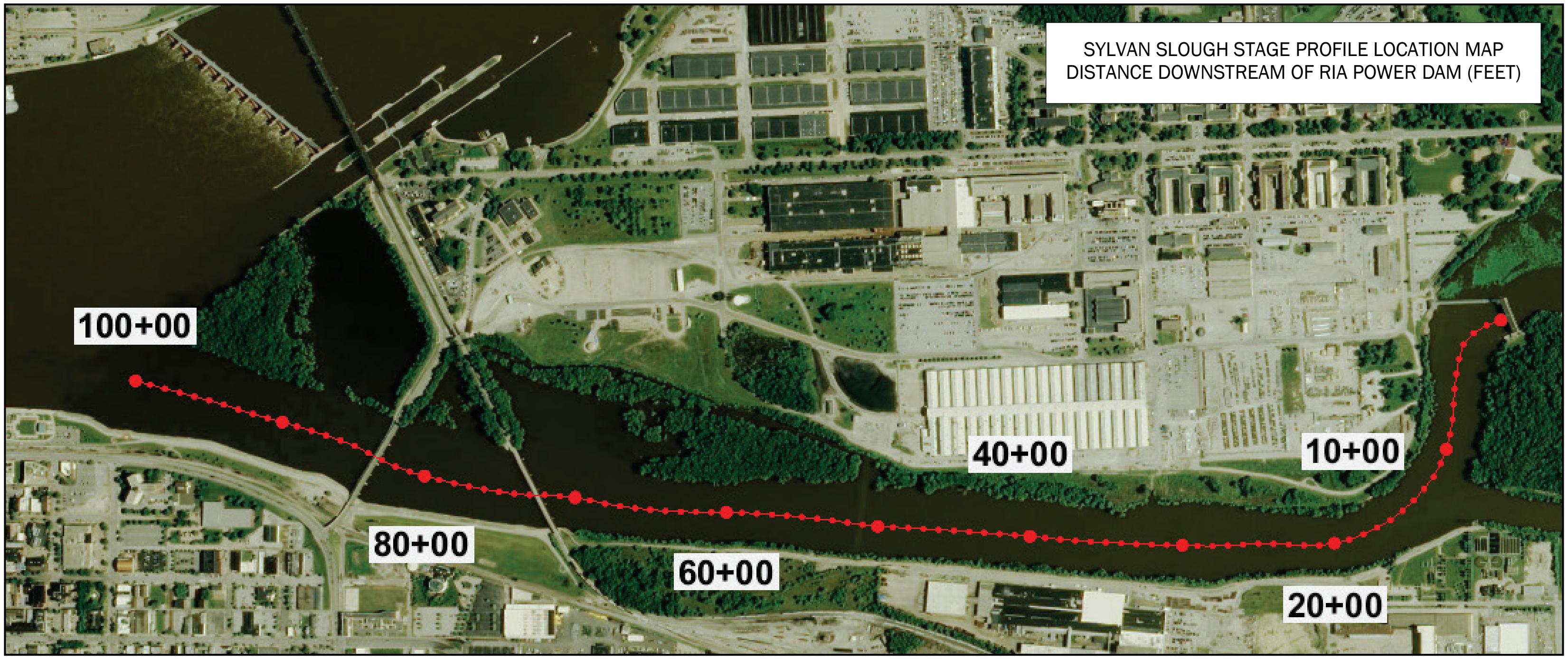

10+00
20+00
40+00
60+00
80+00
100+00
MOLINE POOL STAGE PROFILE LOCATION MAP
DISTANCE UPSTREAM OF RIA POWER DAM (FEET)

Plate 2



Sylvan Slough Stage Profile for Mississippi River Discharge of 35,000 cfs
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
Stage (ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Distance from Arsenal Powerhouse (ft)
A-4.2k cfs M-4k cfs
A-4.92k cfs M-3.1k cfs
A-6k cfs M-2k cfs
A-8k cfs M-0k cfs
A-8k cfs M-2k cfs
A-8k cfs M-4k cfs
A-12k cfs M-4k cfs

Plate 3



SYLVAN SLOUGH STAGE PROFILE LOCATION MAP
DISTANCE DOWNSTREAM OF RIA POWER DAM (FEET)
100+00
80+00
60+00
40+00
20+00
10+00

Plate 4

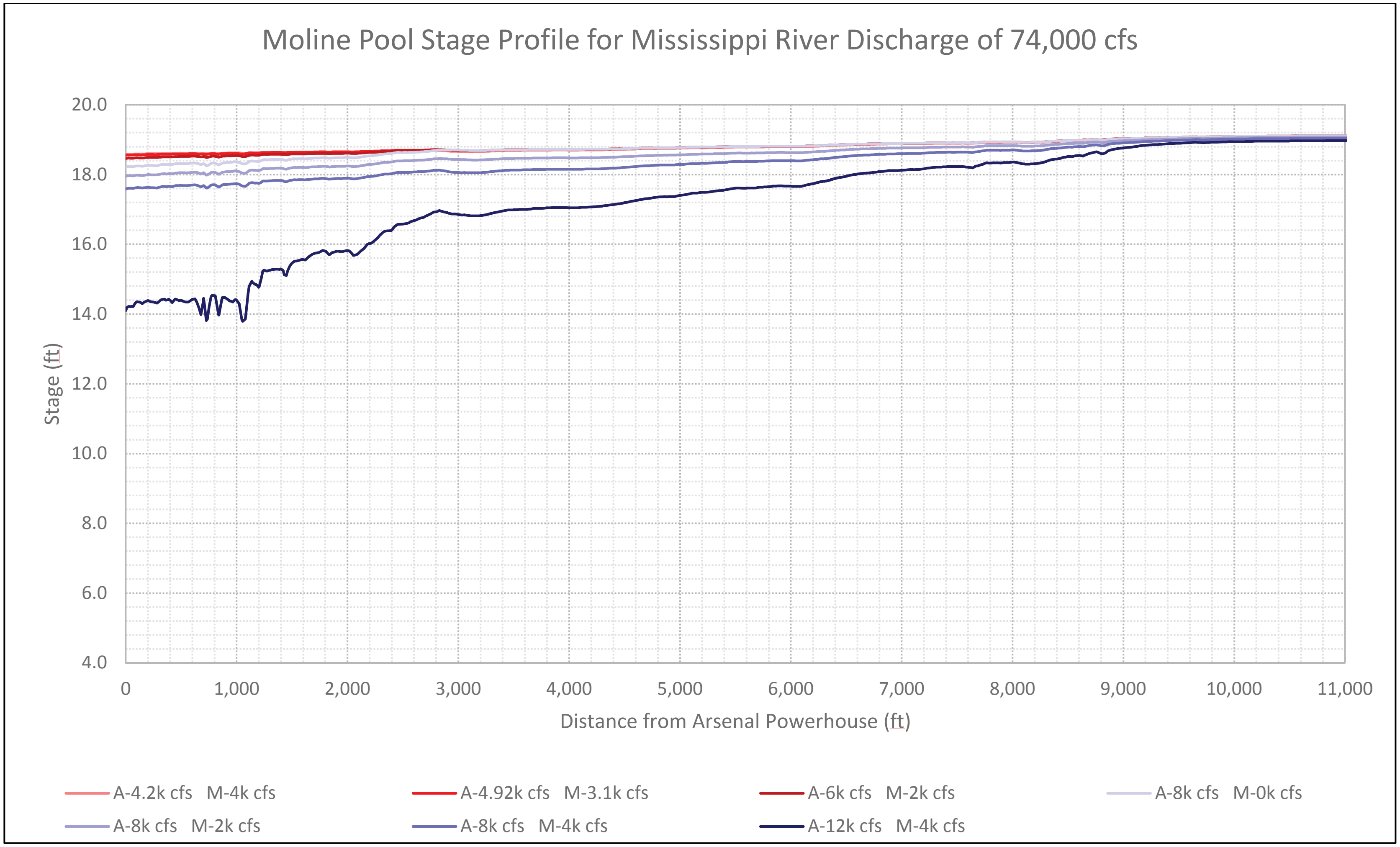
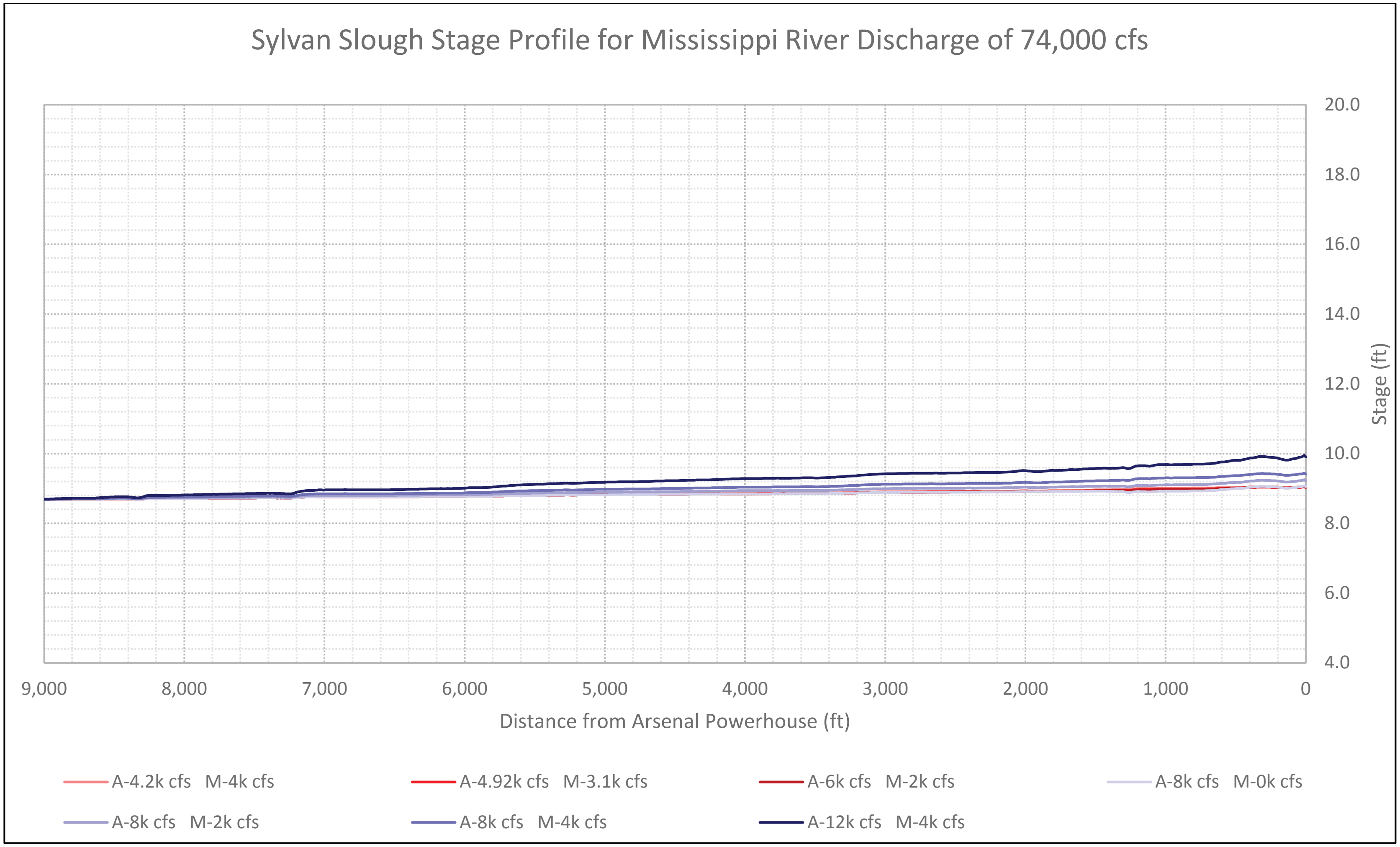

Moline Pool Stage Profile for Mississippi River Discharge of 74,000 cfs
Stage (ft)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
Distance from Arsenal Powerhouse (ft)
A-4.2k cfs M-4k cfs
A-4.92k cfs M-3.1k cfs
A-6k cfs M-2k cfs
A-8k cfs M-0k cfs
A-8k cfs M-2k cfs
A-8k cfs M-4k cfs
A-12k cfs M-4k cfs

Plate 5



Sylvan Slough Stage Profile for Mississippi River Discharge of 74,000 cfs
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
Stage (ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Distance from Arsenal Powerhouse (ft)
A-4.2k cfs M-4k cfs
A-4.92k cfs M-3.1k cfs
A-6k cfs M-2k cfs
A-8k cfs M-0k cfs
A-8k cfs M-2k cfs
A-8k cfs M-4k cfs
A-12k cfs M-4k cfs

Plate 6

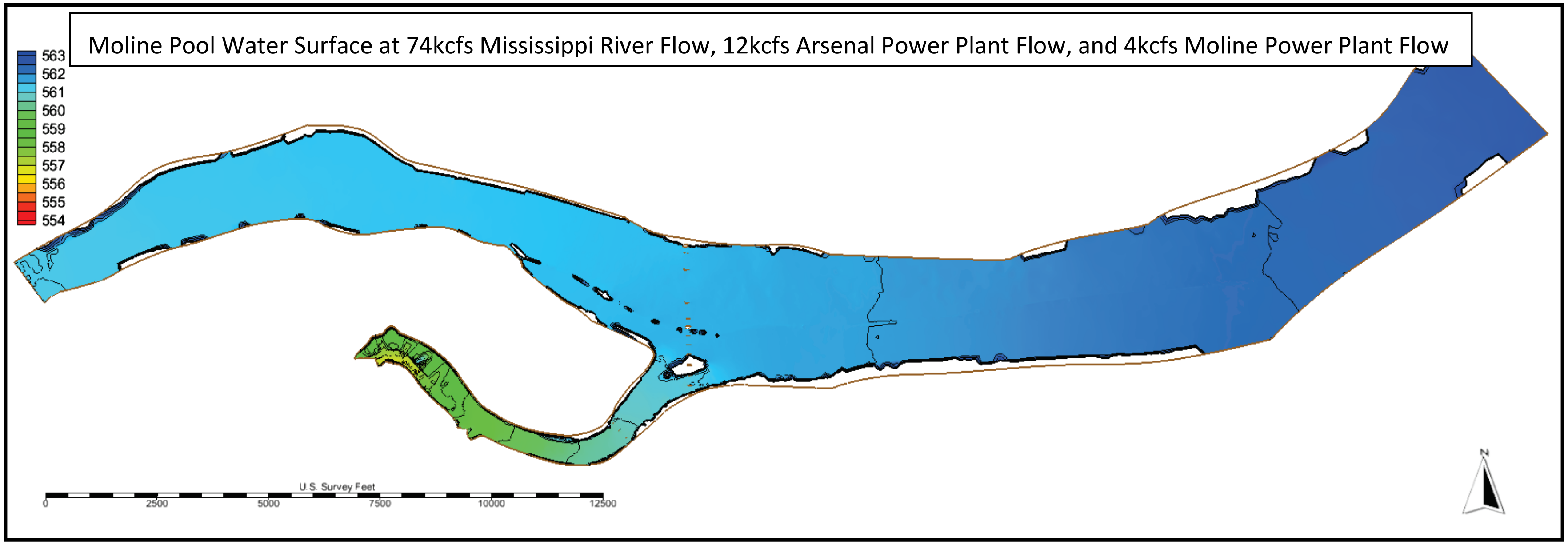
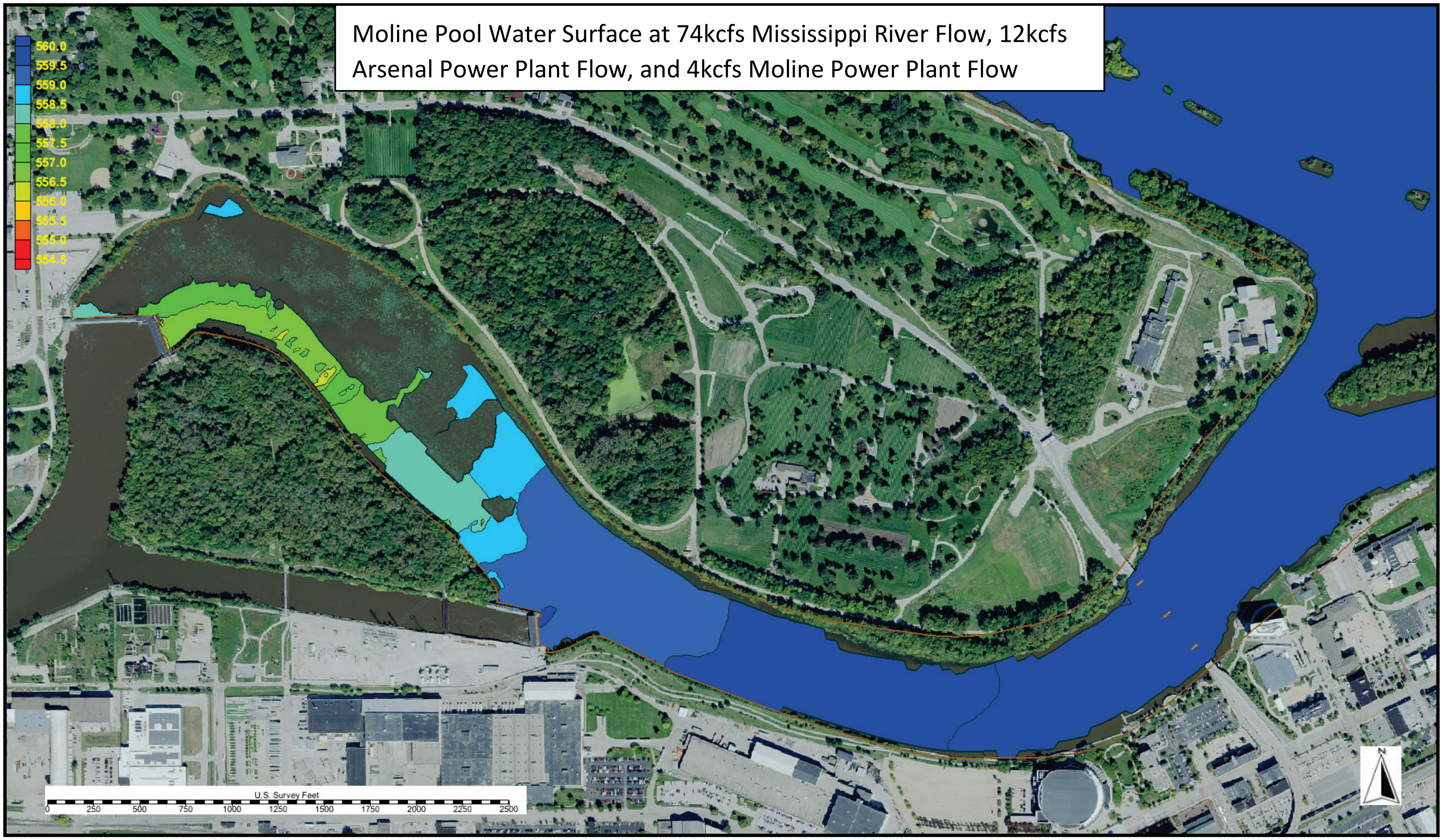

Moline Pool Water Surface at 74kcfs Mississippi River Flow, 12kcfs Arsenal Power Plant Flow, and 4kcfs Moline Power Plant Flow
563
562
561
560
559
558
557
556
555
554
U.S. Survey Feet
0
2500
5000
7500
10000
12500
N

Plate 7


Moline Pool Water Surface at 74kcfs Mississippi River Flow, 12kcfs Arsenal Power Plant Flow, and 4kcfs Moline Power Plant Flow
560.0
559.5
559.0
558.5
558.0
557.5
557.0
556.5
556.0
555.5
555.0
554.5
U.S. Survey Feet
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
N

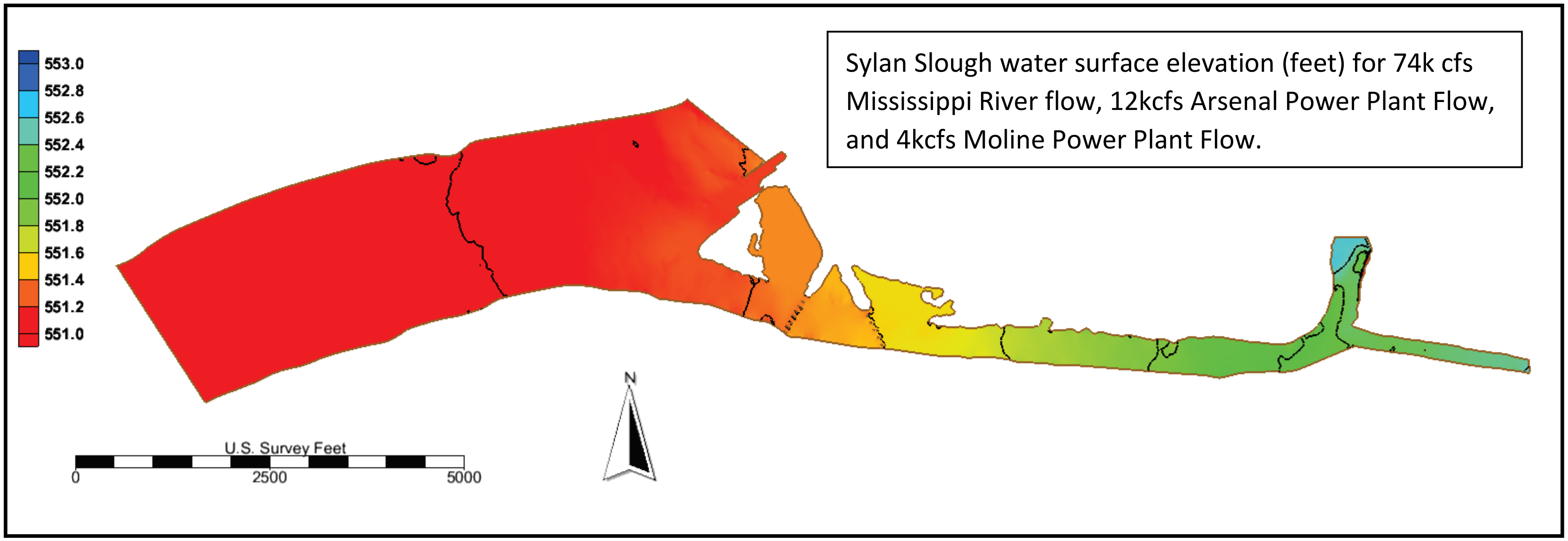

553.0
552.8
552.6
552.4
552.2
552.0
551.8
551.6
551.4
551.2
551.0
Sylan Slough water surface elevation (feet) for 74k cfs Mississippi River flow, 12kcfs Arsenal Power Plant Flow, and 4kcfs Moline Power Plant Flow.
U.S. Survey Feet
0
2500
5000
N

Plate 9

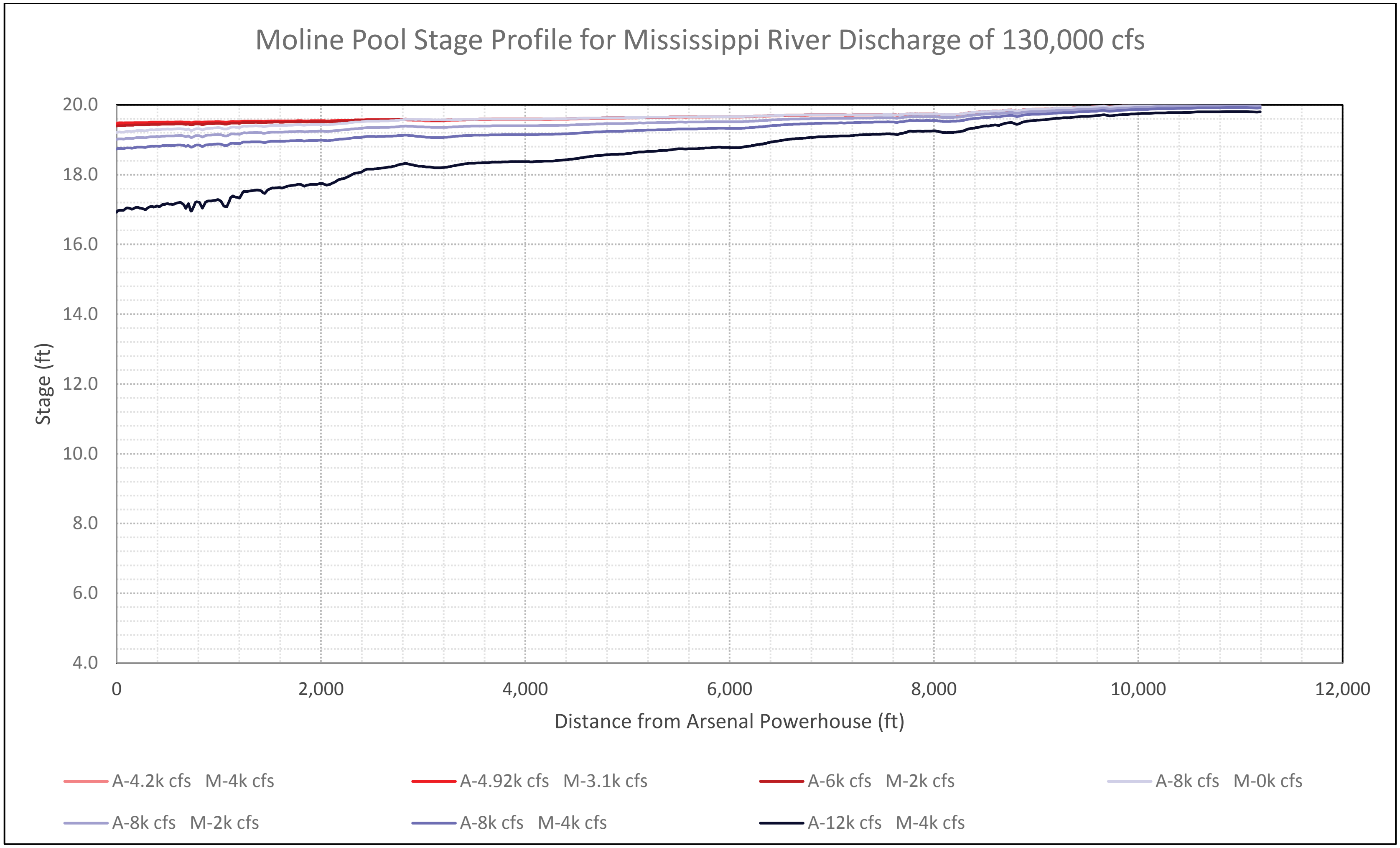
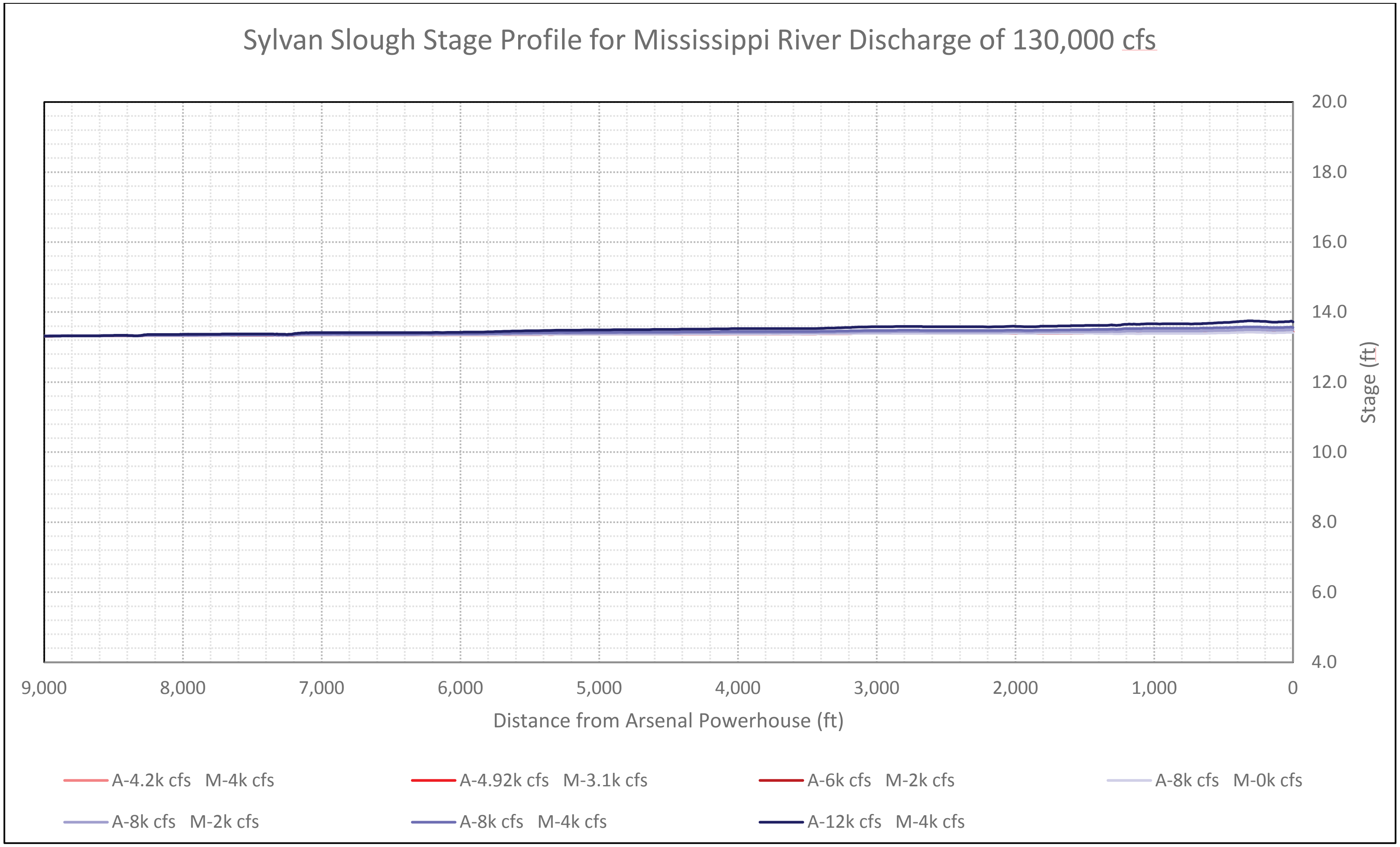

Moline Pool Stage Profile for Mississippi River Discharge of 130,000 cfs
Stage (ft)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
0
2,000
4,000
6,000
8,000
10,000
12,000
Distance from Arsenal Powerhouse (ft)
A-4.2k cfs M-4k cfs
A-4.92k cfs M-3.1k cfs
A-6k cfs M-2k cfs
A-8k cfs M-0k cfs
A-8k cfs M-2k cfs
A-8k cfs M-4k cfs
A-12k cfs M-4k cfs

Plate 10



Sylvan Slough Stage Profile for Mississippi River Discharge of 130,000 cfs
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
Stage (ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Distance from Arsenal Powerhouse (ft)
A-4.2k cfs M-4k cfs
A-4.92k cfs M-3.1k cfs
A-6k cfs M-2k cfs
A-8k cfs M-0k cfs
A-8k cfs M-2k cfs
A-8k cfs M-4k cfs
A-12k cfs M-4k cfs

Plate 11


Modeled Dredging Locations
Legend
Proposed Dredging
0
500
1,000
2,000
Feet
Source: ESRI and USACE; Map: JAH (LRL) 08/31/2015
Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN,
User Community
US Army Corps
of Engineers
Louisville District

Plate 12

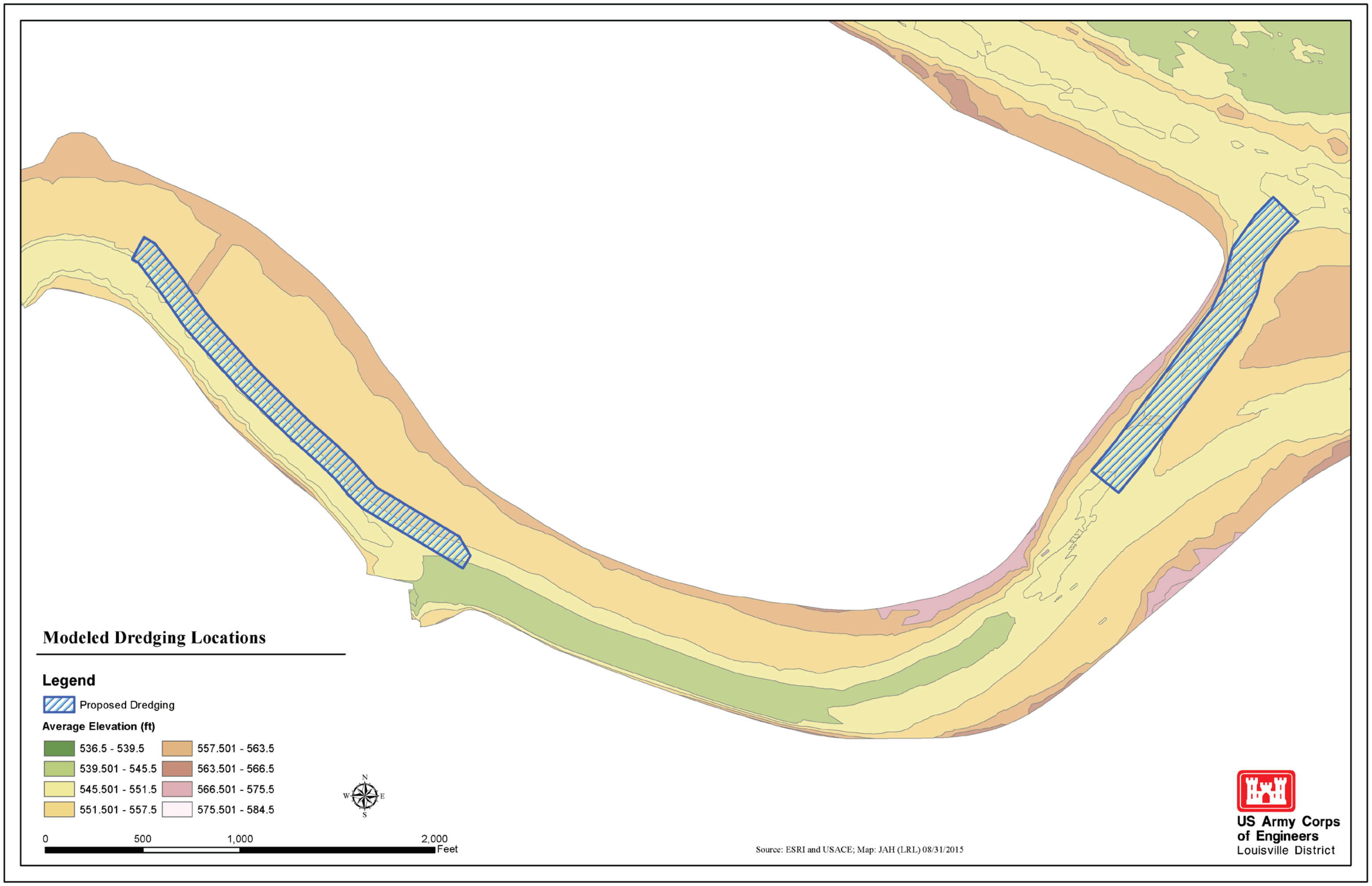

Modeled Dredging Locations
Legend
Proposed Dredging
Average Elevation (ft)
536.5 - 539.5
539.501 - 545.5
545.501 - 551.5
551.501 - 557.5
557.501 - 563.5
563.501 - 566.5
566.501 - 575.5
575.501 - 584.5
N
W
E
S
0
500
1,000
2,000
Feet
Source: ESRI and USACE; Map: JAH (LRL) 08/31/2015
US Army Corps
of Engineers
Louisville District

Plate 13

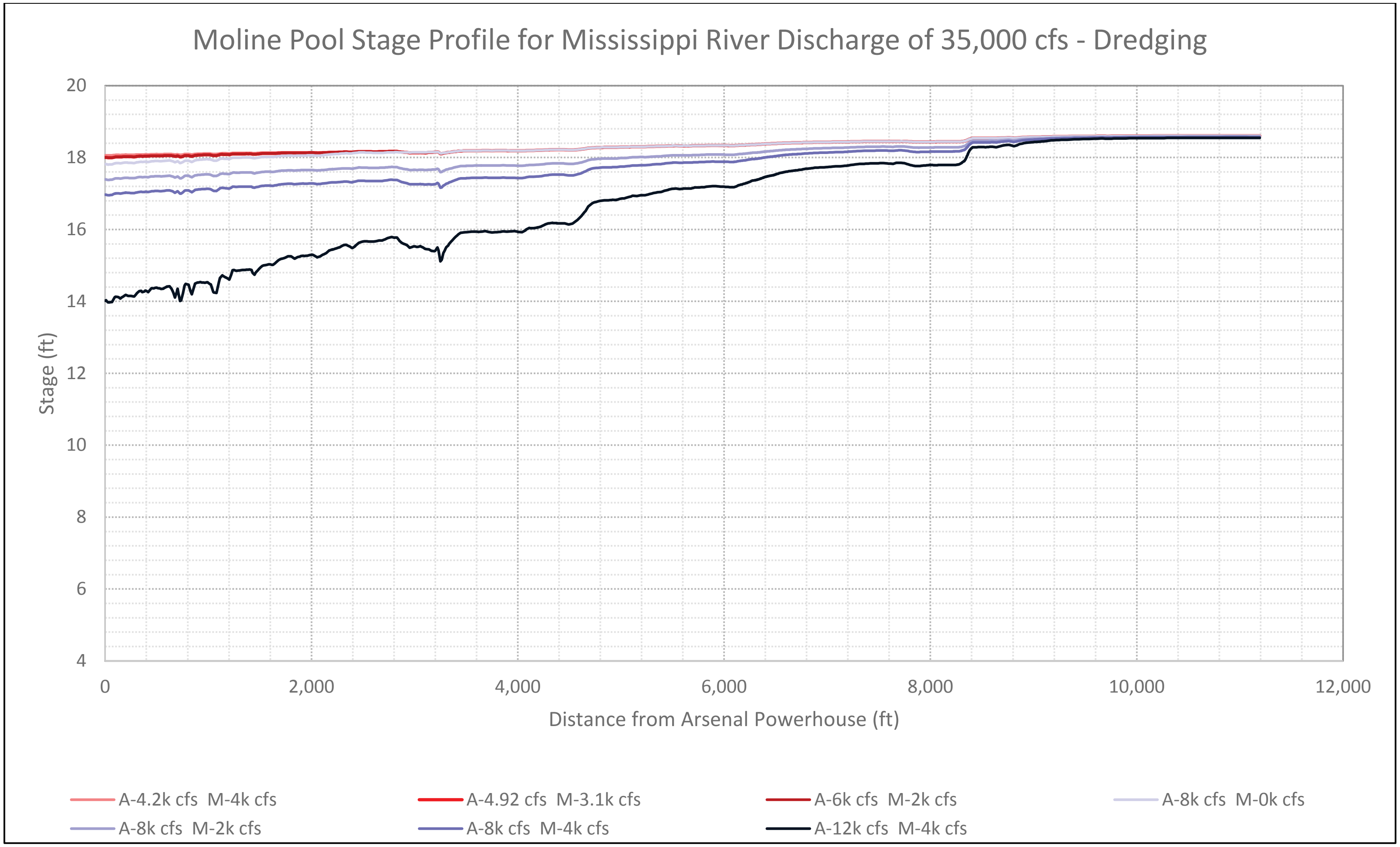

Moline Pool Stage Profile for Mississippi River Discharge of 35,000 cfs - Dredging
Stage (ft)
20
18
16
14
12
10
8
6
4
0
2,000
4,000
6,000
8,000
10,000
12,000
Distance from Arsenal Powerhouse (ft)
A-4.2k cfs M-4k cfs
A-4.92 cfs M-3.1k cfs
A-6k cfs M-2k cfs
A-8k cfs M-0k cfs
A-8k cfs M-2k cfs
A-8k cfs M-4k cfs
A-12k cfs M-4k cfs

Plate 14

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14. ABSTRACT
The Mississippi River at Rock Island, IL, flows through Lock and Dam 15 and two power plants. One power plant is operated by the City of Moline, IL, while the other is under control of the U.S. Army Garrison Rock Island Arsenal. The Rock Island Arsenal is considering upgrades to its generating capacity, and there are questions regarding the impacts of the additional flow in the channel between Rock Island and the City of Moline due to these upgrades. Flow in Pool 15 (Moline Pool) and Pool 16 (Sylvan Slough) was modeled with Adaptive Hydraulics (AdH). The models were run for three different Mississippi River discharge scenarios (35,000, 74,000, 130,000 cfs). Increased discharge from the Rock Island plant had minimal effects in Sylvan Slough until combined power plant discharges exceeded 10,000 cfs. At higher flows, when combined with the 35,000 cfs Mississippi River scenario, the tailwater at both dams starts to increase. The existing capacity of the channel in the Moline Pool effectively limits discharge to 8,000 cfs at low Mississippi River flows. Dredging of the Moline Pool channel would allow larger power plant flows, but there would still be significant decreases in the available head for power generation at all Mississippi River discharges.

15. SUBJECT TERMS
ADH, Hydraulics, Hydropower, Lock and Dam 15, Moline, Mississippi River, Numeric Model, Rock Island Arsenal, Sylvan Slough, Water power

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